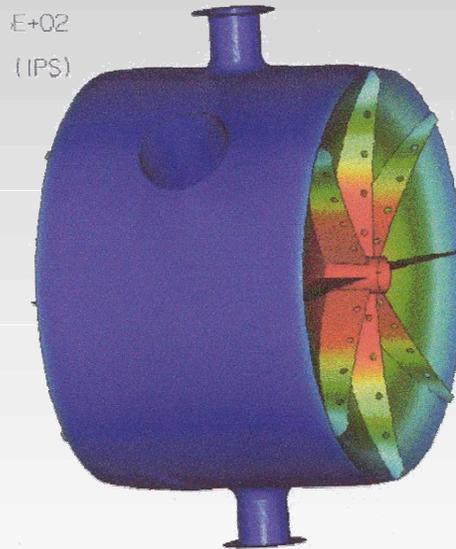


# Microphonics Measurements in Spoke Cavities

**Overcoupling + Negative Phase Feedback or Voltage Controlled Reactance?**

- **Phase-locked loop; Cavity Resonance Monitor**
- **Phase noise**
- **Measurements**

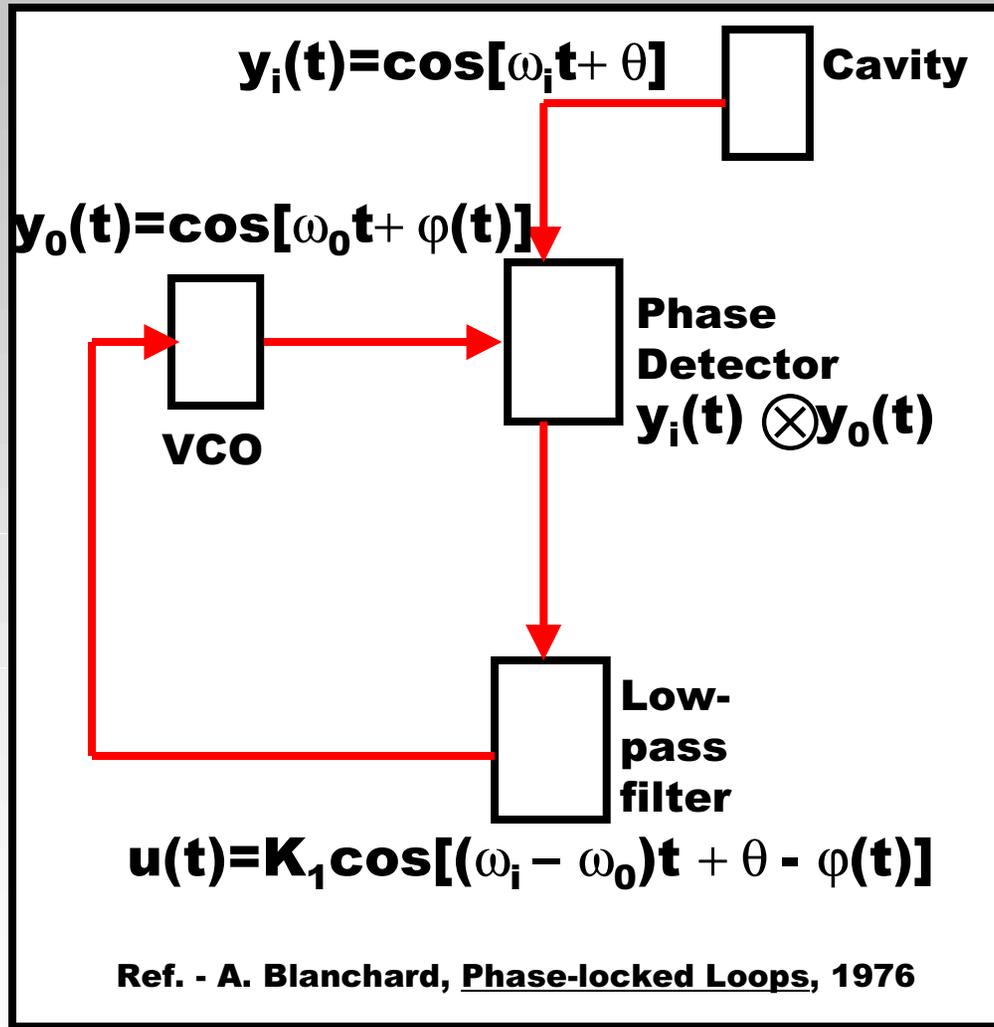


Spoke Cavity Workshop, Oct. 7-8, 2002

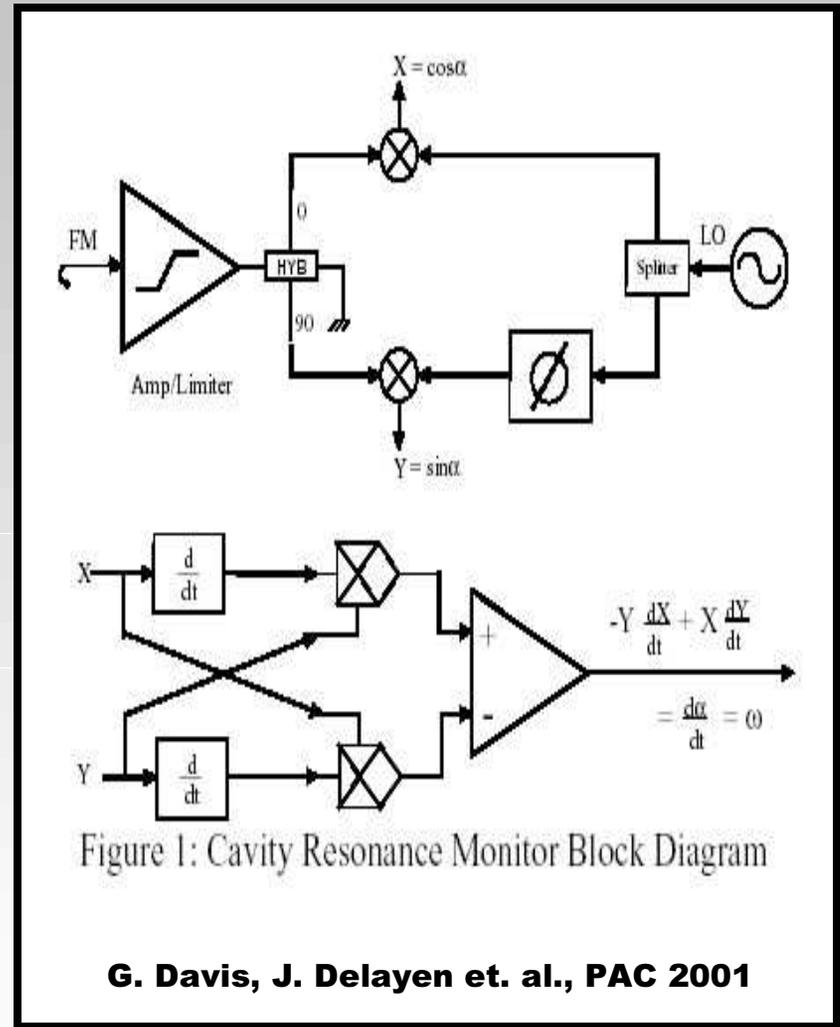
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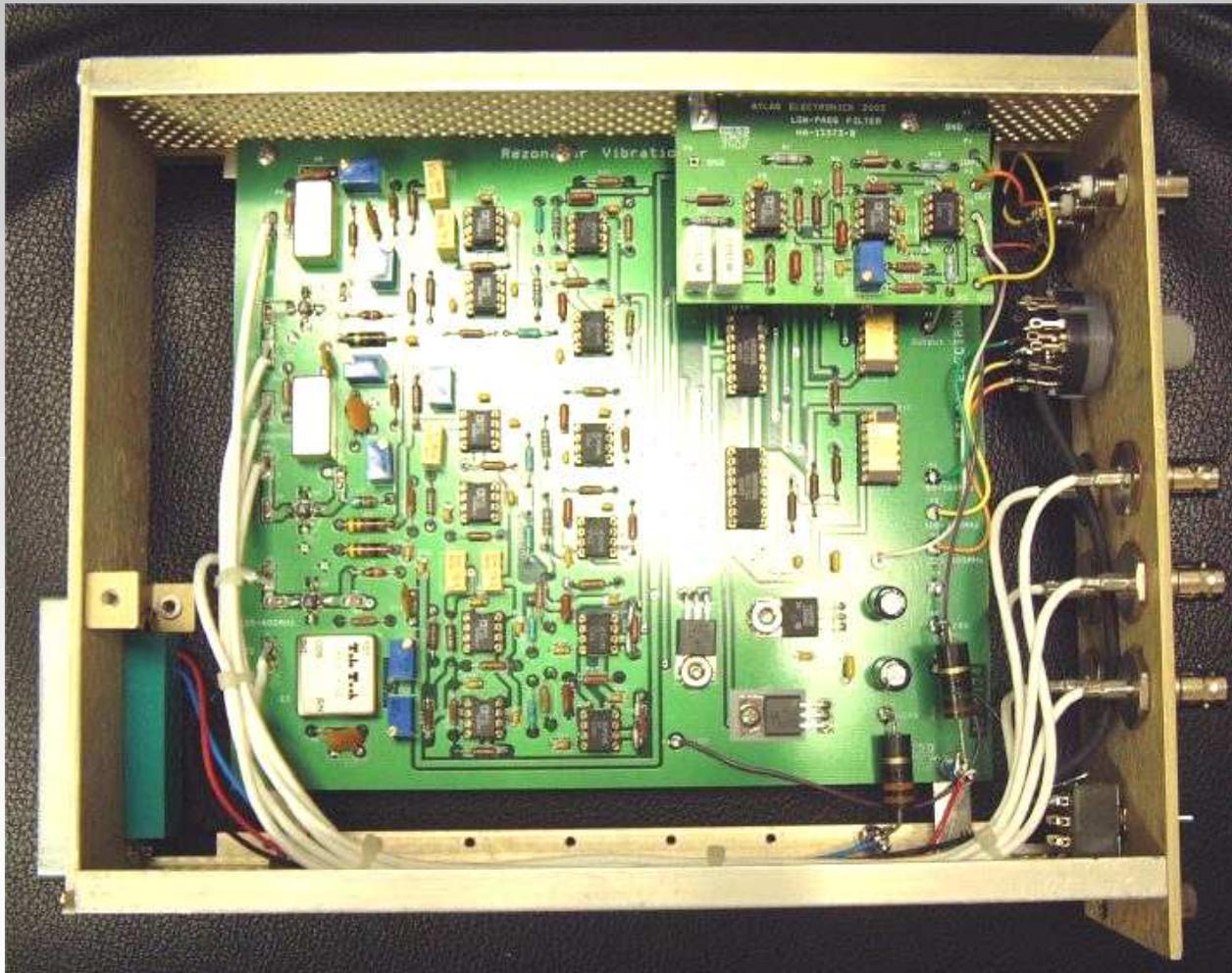
# Phase-locked loop



# Cavity Resonance Monitor



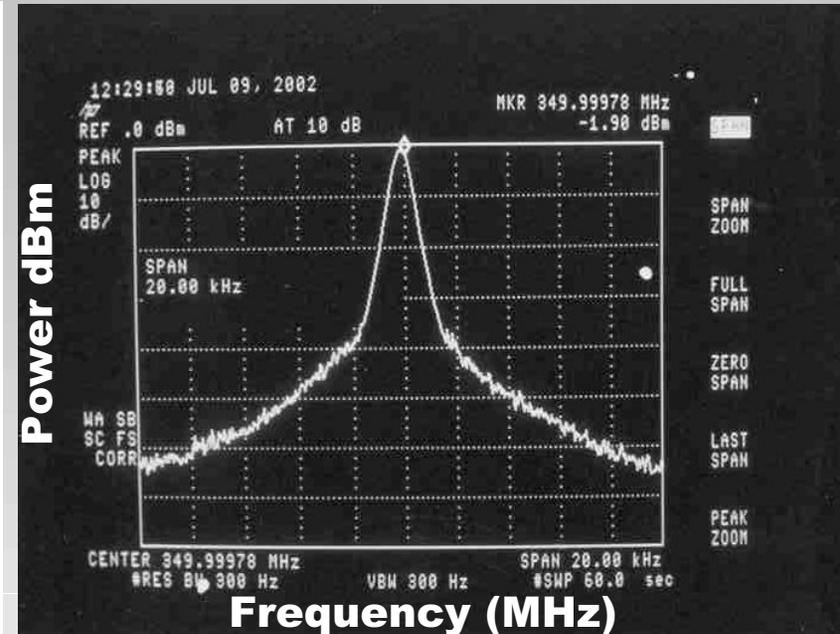
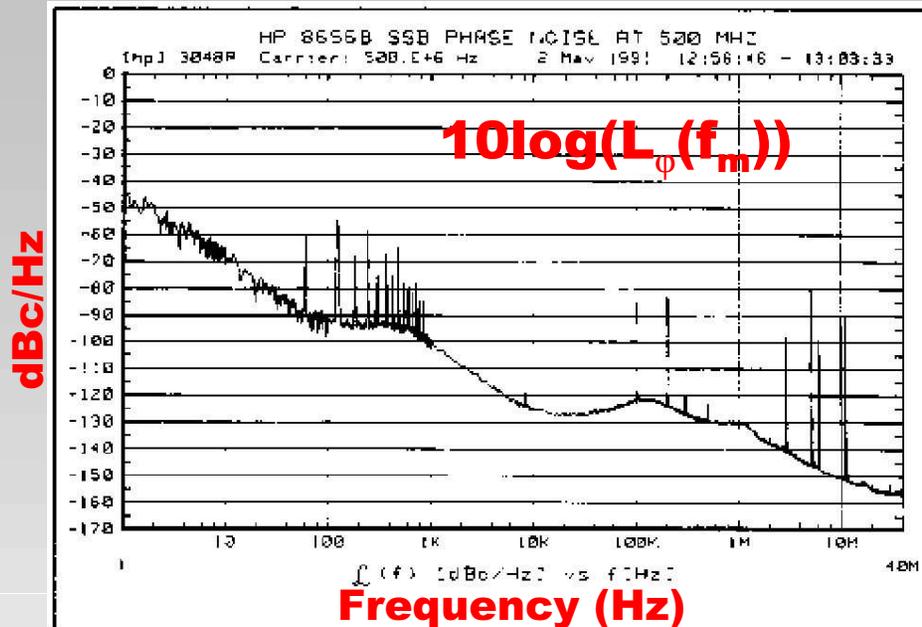
# Cavity Resonance Monitor



**Sergey Sharamentov** [sharamentov@phy.anl.gov](mailto:sharamentov@phy.anl.gov)



# Phase Noise ↔ Frequency Modulation



$$y_i(t) = \cos[\omega_i t + \phi \sin \omega_m t]$$

$\phi$  is the peak amplitude of phase modulation  
for a modulating frequency  $\omega_m$

$$\text{Cavity frequency} = \omega_i + \omega_m \phi \cos \omega_m t$$

$$\omega_{\text{peak}} = \omega_m \phi$$



# Frequency Modulation from Phase Noise

$$\omega_{\text{peak}} = \omega_m \varphi$$

Relates peak freq. modulation to peak phase modulation

$$S_f(\omega_m) = \omega_m^2 S_\varphi(\omega_m)$$

Power density of freq. oscillation vs. phase oscillations

or

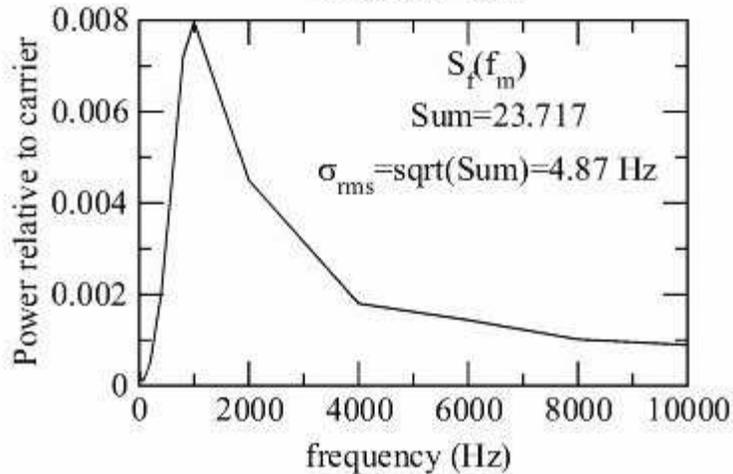
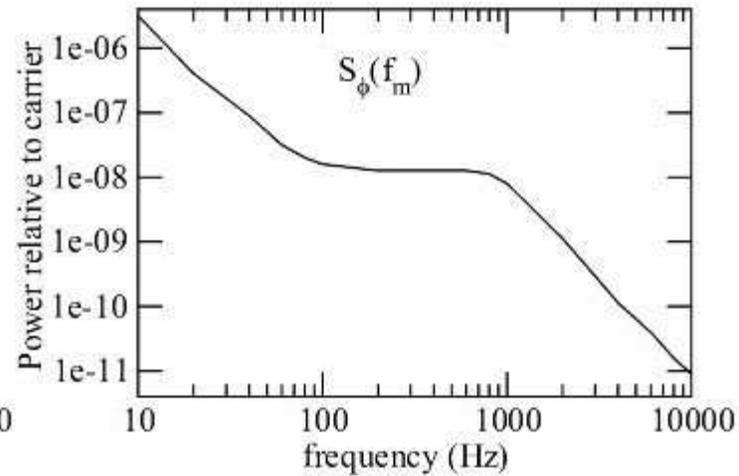
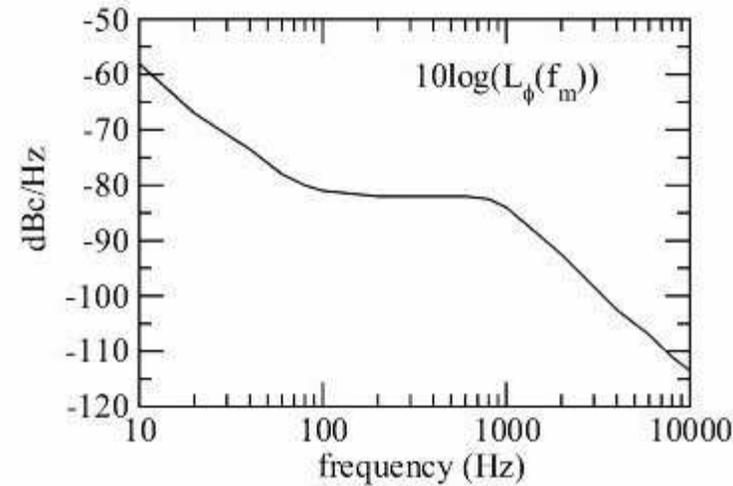
$$S_f(f_m) = f_m^2 S_\varphi(f_m)$$

$$\sigma_f = \sqrt{\int_{f_1}^{f_2} S_f(f_m) df_m}$$

RMS frequency deviation



# HP 8656B FM from Phase Noise Spec



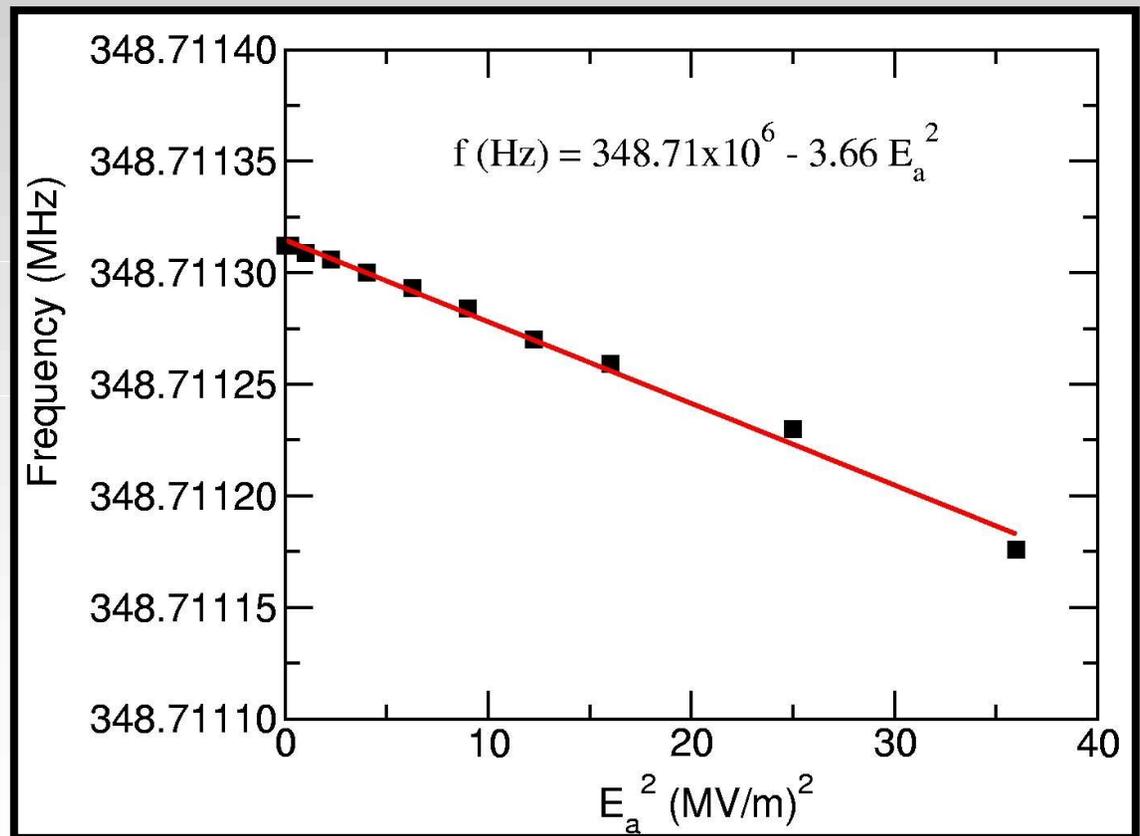
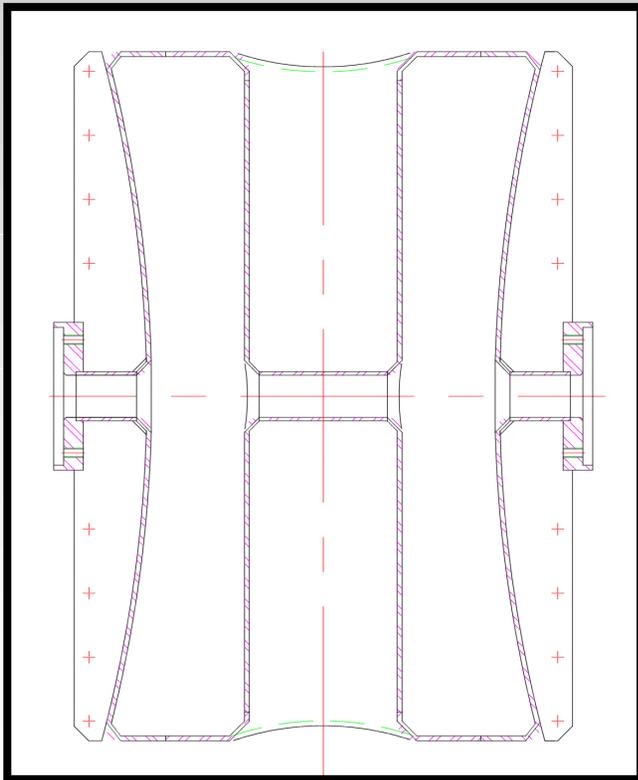
**Actual Measured value  
From error signal  
~ 15 Hz  
Due to spurs at line  
frequency**

**Agilent 8665 about factor of 10 better**



# Some $\beta=0.4$ Spoke Cavity Mechanical, EM Properties

- **Stored Energy 82 mJ,  $E_{\text{PEAK}}=4$  MV/m,  $B_{\text{PEAK}}=107$  G at  $E_{\text{ACC}}=1$  MV/m**
- **Active length 23 cm**
- **RRR~150, ~2.8 mm average thickness after processing**
- **Pressure sensitivity 120 kHz/atm at 4 K (~10% higher warm)**
- **Lorentz detuning 3.7 Hz/(MV/m)<sup>2</sup>**



# Low-lying acoustic modes from FEA (J. Fuerst)

Spoke moving in and out



End wall vibration

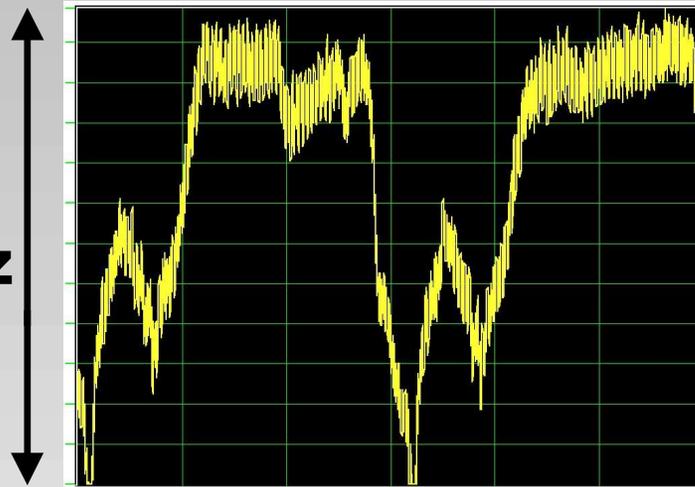
Beam port vibration

Mode		Frequency (Hz)
1		259
2		279
3		315
4		360
5		398
6		422
8		461
11		488
16		723
17		727



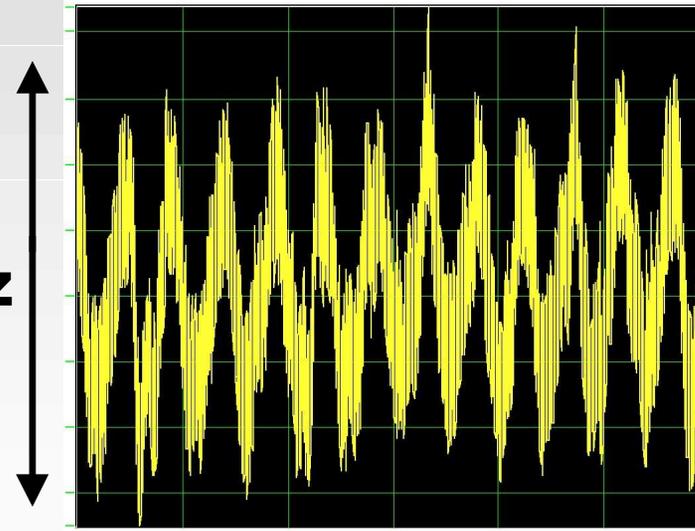
# Refrigerator Effects: PLL Error Signal 6/28/02

$\Delta f = 1150 \text{ Hz}$



2800W refrigerator set up with 2 watts excess capacity with 1S loaded at 2800 rpm and 8S unloaded. L dewar pressure 2.4 psig

$\Delta f = 280 \text{ Hz}$



Refrigerator conditions are 60 watts excess capacity. L pressure = 2.8 psig. 1S loaded at 3600 rpm & 8S unloaded.

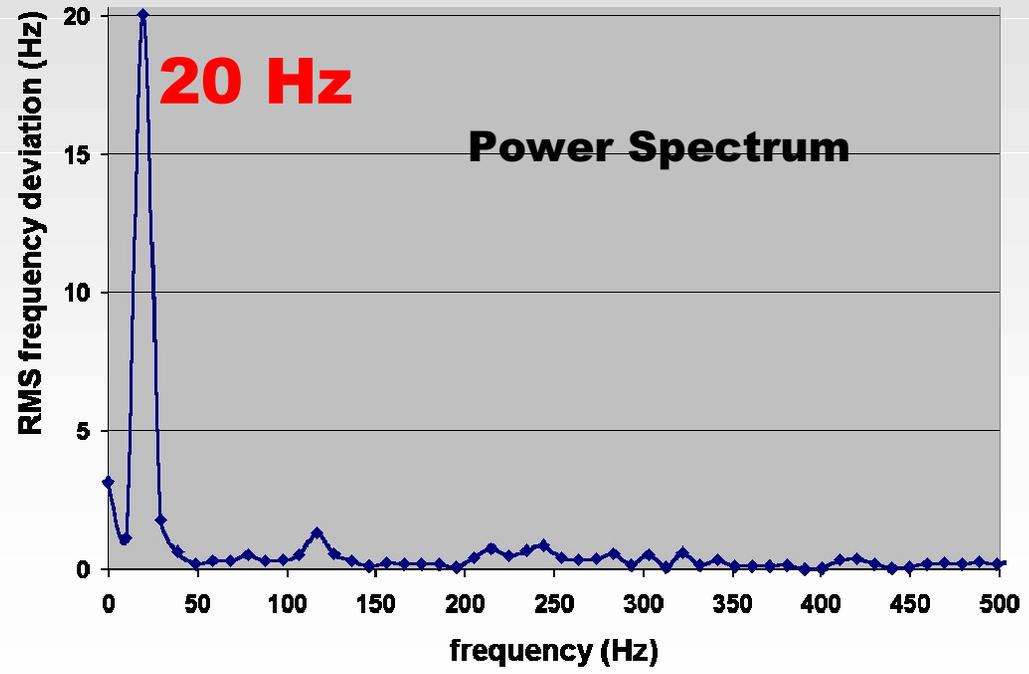
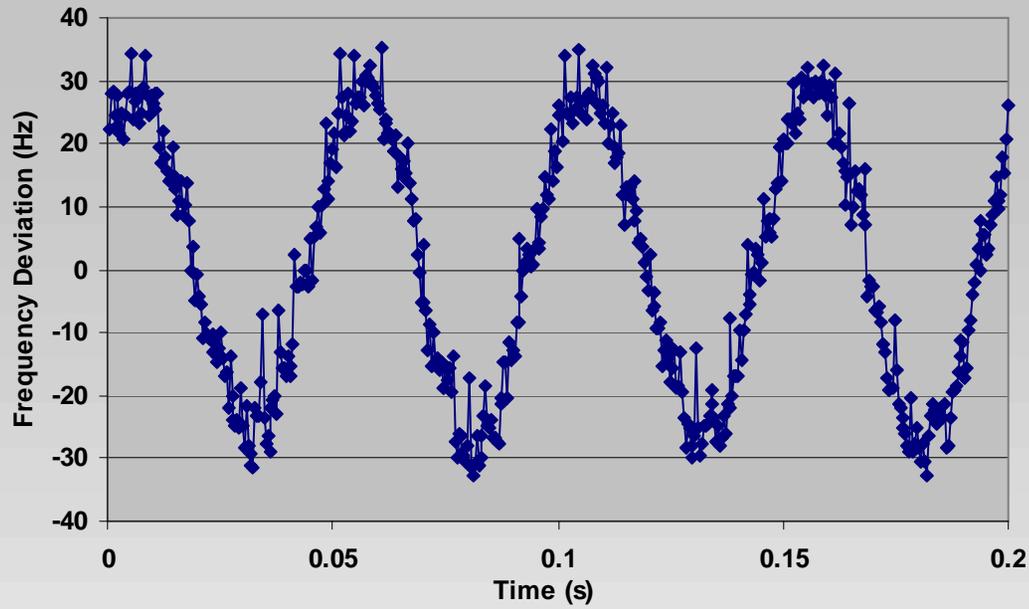
300 seconds

**300 seconds**

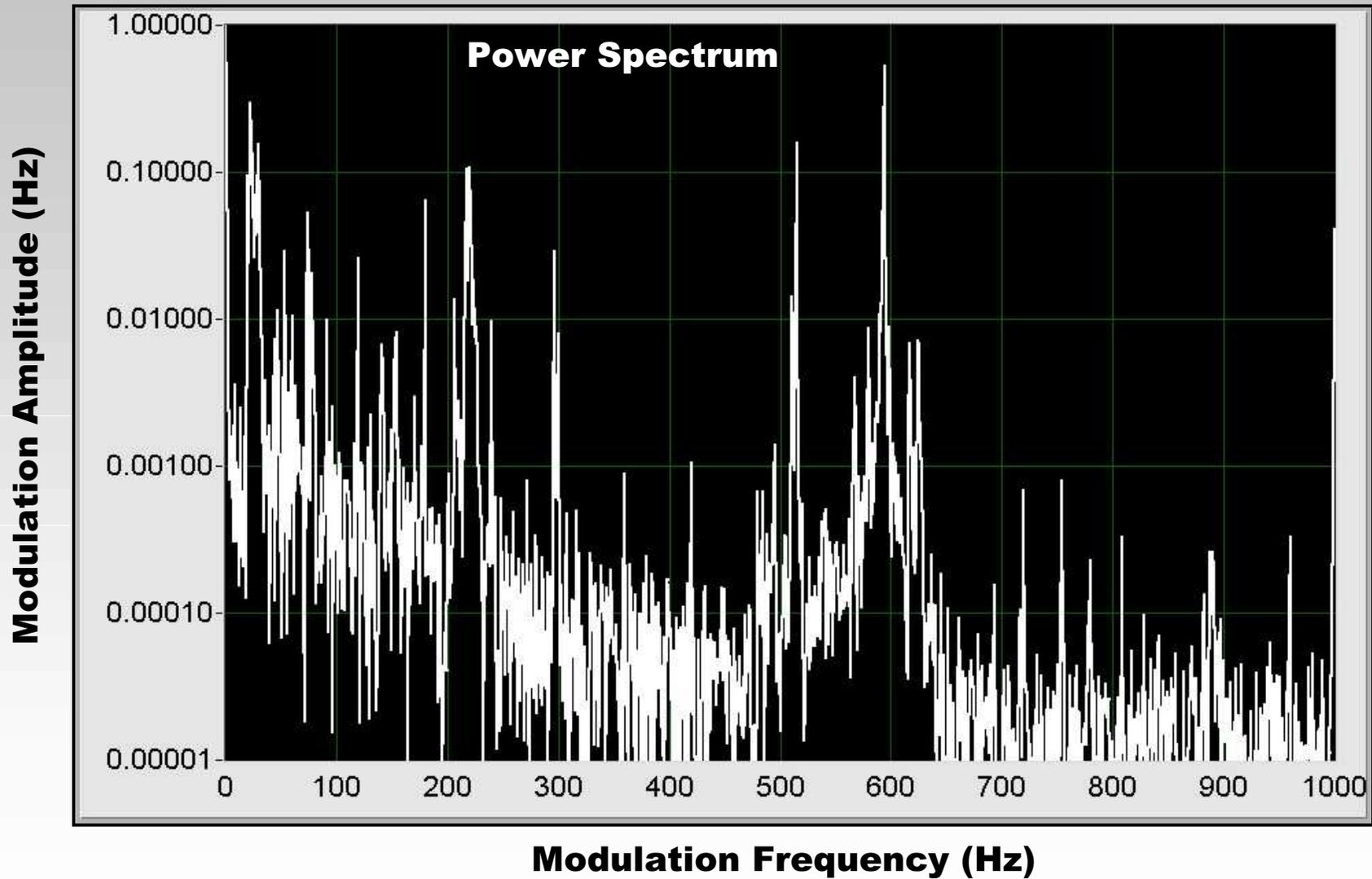


# Spoke Cavity PLL Error Signal: Thermal-acoustic oscillation

6/24/02



# Single Spoke w/ Cavity Resonance Monitor 8/8/02



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# Single Spoke w/ CRM: 50 sec. At 11 kHz

